Urban traffic incident management in a digital society. An actor-network approach in information technology use in urban Europe

Steenbruggen, J.G.M.; Nijkamp, P.; van der Vlist, A.J.

2013

document version
Early version, also known as pre-print

Faculty of Economics and Business Administration

Urban traffic incident management in a digital society.
An actor-network approach in information technology use in urban Europe

Research Memorandum 2013-5

John Steenbruggen
Peter Nijkamp
Maarten van der Vlist

vrije Universiteit amsterdam

URBAN TRAFFIC INCIDENT MANAGEMENT IN A DIGITAL SOCIETY
An actor-network approach in information technology use in urban Europe

John Steenbruggen
VU University
Department of Spatial Economics
De Boelelaan 1105
1081 HV Amsterdam. The Netherlands
Phone: +31 152757301
john.steenbruggen@rws.nl

Peter Nijkamp
VU University
Department of Spatial Economics
De Boelelaan 1105
1081 HV Amsterdam. The Netherlands
Phone: +31 205986090
pnijkamp@vu.nl

Maarten van der Vlist
Ministery Infrastructure and Environment
Zuiderwagenplein 2
8224 AD Lelystad. The Netherlands
Phone: + 31 652596328
maarten.vander.vlist@rws.nl

Abstract
In the last two decades, traffic Incident Management (IM) has become an advanced new tool to reduce and prevent congestion on the road network, especially in urban areas. IM involves the coordinated interactions of many public and private actors. To support these tasks in an effective way, advanced information systems are increasingly important. This paper offers a broad overview of the principles and practices of IM, with particular reference to the Dutch situation. It aims to provide an empirical analysis of the critical success conditions for effective IM in the Netherlands based on an Internet survey questionnaire administered to stakeholders.

Keywords: traffic incident management, organization, information systems, actor-network approach

1. INTRODUCTION

Only a few centuries ago, 20 per cent of the worlds population lived in cities. With more than half the population living in urban areas since 2007, there is a gradual transition of our society towards what has been called the 'urban century'. This transition is continuing with urbanization rates exceeding 70 per cent in various European countries (Mega, 2010). This mega-trend in population movement towards the city is the result of an exponential growth in world population and a rural-urban drift (Nijkamp and Kourtit, 2011). According to a European Commission (2010) report, the urbanization rate may have risen to about 80 per cent in the EU. The phenomenon of the 'Urban centuary' raises many research and policy concerns.

Clearly, policy makers have made many efforts in the last 20 years to design policies which promote the use of Information and Communication Technologies (ICT) in order to realize sustainable urban development. The digital revolution enabled cities and policy makers to realise the link between ICT and urban development. As a result, various forms of city concepts have been developed including such as; *wired cities* (Dutton, 1987); *technocities* (Downey and McGuigan, 1999); *creative cities* (Florida, 2005); *knowledge-based cities* (Carrillo, 2006); *real-time city* (Townsend, 2000; Calabrese *et al.*, 2011); *WIKI cities* (Calabrese *et al.*, 2007; Ratti *et al.*, 2007); *digital cities* (Komninos, 2008), *Live City* (Resch *et al.*, 2012) and one of the latest concepts is the *smart city*.

Smart cities can be defined as "territories with a high capacity for learning and innovation, which results from the creativity of their population, their institutions of knowledge creation, and their digital infrastructure for communication and knowledge management" (Komninos, 2006). The term 'smart city' is often used interchangeably with *intelligent*, *wired*, or *digital* city. Hollands (2008) provides a comprehensive review on the smart city concept. The role of ICT is the main smart city subject discussed in the literature. Smart cities are mostly related with the design and applications of ICT – both as digital infrastructure and ICT usage – at the level of cities and regions (Komninos, 2002). Digital technologies have changed our ways of living and working. For example, the relationship between physical travel and telecommunications has been studied extensively in the literature as an objective to understand the direction in which the use of telecommunications influence mobility behaviour (Nobis and Lenz, 2009). Mokhtarian (2003) has identifies four possible relationships between physical travel and telecommunications: *Substitution*, c*omplementarity*, *modification*, and *neutrality*.

There is a great potential for digital technologies which should be exploited for the better management of complex urban systems. These systems are marked by connectivity and accessibility, and need to be governed from a systematic perspective in which ICT may plays an important role. An important problem in densely-populated urban agglomerations is the vulnerability caused by traffic accidents. This paper aims to map out critical success factors of Incident Management (IM) which is based on advanced digital technologies. The paper presents the results from an empirical application of IM in the urbanized part of the Netherlands. It starts of with a broad overview of IM, with particular emphasis on the Dutch situation. It then highlights the regulatory framework involved with effective traffic IM. The critical success factors are derived by using an Internet survey questionnaire administered to the relevant stakeholders. The overall aim of this paper is to address the role of traffic IM, with the goal to reduce and prevent congestion on the road network, especially in urban areas. Section 2 describes the challenges to reduce the inefficiencies of present-day urban systems. In Section 3, we first look at developments in the Netherlands in terms of regulation, policy, mobility, and safety issues. Section 4 focusses in more detail on the public and private actors involved, and the emergence of the information chain based on an actor-network approach. In Section 5 we present our main findings from the Internet survey. Finally, in Section 6, we analyse the increasingly important role of information, and the introduction of new information concepts to support traffic IM.

2. TRAFFIC INCIDENT MANAGEMENT

Europe has a relatively high population density, and consequently also a dense transportation network, especially in and around urban agglomerations in Western Europe. This region is one of the most urbanized areas in the world. High density networks may become vulnerable in peak hours. This prompts the question whether information technology can be instrumental in guaranteeing these networks a smooth throughflow in urban areas. Road networks are part of a country's transport infrastructure, and are therefore subject to general transport policies. Traffic incidents have a significant impact on the normal operation of road networks. This impact has a vast effect on all road users and the surrounding community. Casualties need to be recovered quickly from the scene of an incident, and secondary incidents need to be avoided. Traffic delays due to incidents result in loss of time, disruptions to public transport schedules, financial loss to freight operators and businesses, and increased vehicle emissions due to traffic idling for extended periods of time.

An 'incident' is generally defined as "*an unforeseen (unpredictable) event that impacts on the safety and the capacity of the road network and that causes extra delay to road users*" (EasyWay, 2011). The term 'incident' is defined in the Dutch regulatory framework as "*all the events (such as accidents, dropped cargo, stranded vehicles, collisions with incidents involving hazardous materials), which affect (or may affect) the capacity of the road and hinder the smooth flow of traffic with the exception of broken down vehicles on the hard shoulder, where there is a minimal and acceptable risk regarding the traffic flow and safety of the other traffic*" (Dutch Ministry of Transportation and Water Management, 1999). Each EU Member State has its own strategy and definitions for handling traffic incidents (Dutch Ministry of Transportation and Water Management, 1999; ECMT, 2007; UK HWA, 2009; CEDR, 2011; EasyWay, 2011). Central in all these definitions are the planned and coordinated measures for safe and quick restoration to normality. IM is, in general, the policy that, through a set of measures, aims to reduce both the negative effects on the traffic flow conditions and the effects on safety, by shortening the period needed to clear the road after an incident has happened. It can also been seen as a process to detect, respond, and remove traffic incidents, and to restore traffic capacity.

The handling of an incident can be described on the basis of the activities necessary to reduce the damage caused by an incident. This serves to show where problems arise in the clearing of incidents, and is useful for determining what measures are needed (Knibbe *et al.*, 2006; Immers *et al.*, 2009). In the literature there is no general agreement on the different phases of IM (see Table 1; Özbay and Kachroo, 1999; Nam and Mannering, 2000; Corbin and Noyes, 2003; US FHWA, 2000; Dutch Ministry of Transportation and Water Management, 2005a; UK HWA, 2009). In our analysis, we use Zwaneveld *et al*.'s (2000) simplified version of IM phases, which comprises four phases: alerting; response and arrival; action; and normalization. In some examples, the detection and warning phase are combined. In the literature, sometimes the normalization and flow recovery time are also combined into one phase. The verification phase is also an important process. However, in many examples, this phase is not included. An attempt to create a shared European agreement on the process phases can be found in CEDR (2011).

Table 1: Differences in the definition of traffic IM process phases

United States Federal Highway Administration (2000)	**Europe CEDR (2011)**	**Europe EasyWay (2011) Deployment guide**	**Netherlands Zwaneveld *et al.* (2000)**	**Netherlands Dutch Ministry of Transportation and Water Management (2005a)**
detection	discovery	discovery	detection	alerting
verification	verification	verification		
response	initial response	initial response	warning	response
			driving or arrival	
site management	scene management	scene management	operation or action	action
clearance	recovery	recovery	normalization	normalization
	restoration to normality	restoration to normality	flow recovery	
	normality			

Strategies to prevent incidents are, of course, preferable to strategies designed to respond to incidents. In many cases, human or technical failure plays an important role (Wegman, 2007). The main causes of road deaths are speeding, driving under the influence of alcohol or drugs, and not using seat belts[1]. Governments need to ensure that comprehensive laws cover the main risk factors (World Health Organization, 2009; European Transport Safety Council, 2011).

Traffic IM can be seen as a special case of (simplified) crisis or disaster management in terms of organization and work processes. Disaster management involves a cycle which should consist of an organized effort to mitigate against, prepare for, respond to, and recover from a disaster (FEMA, 1998). Informed decisions are a prerequisite for the formulation of successful mitigation, response, preparedness, and recovery strategies. To a great extent, however, successful strategies depend on the availability of accurate information presented in an appropriate and timely manner (Grothe *et al.*, 2005). This is more or less in line with traffic IM. Cooperation between the emergency services, in terms of coordination, communication, and information-sharing, is becoming increasingly important in order to apply traffic IM successfully. The emergency services have traditionally been alerted and have shared information via traditional landline and mobile phone calls. Historically, each organization has developed information systems which are primarily designed as closed systems that mainly support their own specific IM tasks. Even within organizations there are still many problems in terms of system diversity, architecture, and standards used. However, organizations have begun to realize that introducing new interoperable system concepts is important for significantly improving cooperation. It is important to observe that almost all information has a spatial (geographical) component, so that geo-science tools – especially in urban areas – play a crucial role for developing innovative ICT tools for traffic IM. We now provide a concise overview of recent IM developments in the Netherlands.

3. IM DEVELOPMENTS IN THE NETHERLANDS

3.1. Introduction

The origin of traffic IM can be found in the US (Koehne *et al.*, 1991). To "keep Washington on the move", an Incident Response (IR) programme has been initiated by the Washington State Department of Transportation (WSDOT), which started as a pilot in 1990. Washington

[1] http://ec.europa.eu/transport/road_safety/topics/behaviour/index_en.htm

is a state of contrasts: on the one hand, the state has vast unpopulated areas. On the other hand, it has a number of large urban areas which have major mobility problems. In the north-western part of Washington, Seattle and Tacoma form a large conurbation. Vancouver in the south-west of Washington is a part of the cross-state Portland conurbation. The Seattle-Tacoma conurbation is most comparable with the Dutch traffic situation in terms of mobility problems. This area is a vast metropolitan area that has a population of about 3.2 million. The size and population density of the Seattle-Tacoma metropolitan area are roughly comparable with that of the northern part of the main Dutch urban area, the Randstad (Lassche and Jacobs, 2009). In 1991, the Washington State Department of Transportation commissioned a study that led to the "*Framework for developing Incident Management Systems*" (US FHWA, 1991)[2].

The US definition of Traffic IM is "*a planned and coordinated process to detect, respond and remove traffic incidents and restore traffic capacity as safely and quickly as possible*" (US FHWA, 2000). Events like September 11 in 2001 and the widespread impacts of major weather events like Hurricane Katrina in 2005 caused the realignment and redefinition of traffic IM, and underscored its critical role in national preparedness. Transportation agencies are recognizing that traffic IM is more than just a tool for increasing mobility and reducing congestion. In 2003, the U.S. Department of Homeland Security developed the National Incident Management System (NIMS)[3] which provides a framework for incident planning and response, at all levels, regardless of cause, size, or complexity (US Department of Homeland Security, 2008). All incident responders came to understand that it is increasingly important to be aware and understand each other's role, regardless of incident size or scope. The Netherlands is the first country in Europe where a formal structure for IM was introduced in the early 1990s.

3.2. Regulation on mobility and safety

In the Netherlands, the Ministery of Infrastructure and Environment is responsible for public works, transport, and water management, which includes the maintenance of the primary road network of 3,249 km, ensuring that the infrastructure is safe and in a good state, and that the flow of vehicles is as smooth as possible. The Dutch national government has only limited possibilities to enforce strict rules regarding IM because of the large number of involved organizations and the many laws that (in-) directly deal with IM. Therefore, IM was built upon the existing rules and responsibilities of the parties involved. The first policy rules focussed more on mobility issues. Later, the policy rules focussed more on the safety of emergency workers and road users, and on specific measures for towing services. A clear list of priorities has been set in mutual agreements between the emergency services (Dutch Ministry of Transportation and Water Management, 2005a; 2007).

Regulating the traffic flow around incidents by means of regional traffic centres, and ensuring the safety of the people involved are the most important tasks of the road inspectors, which is a task for the Police in normal situations. Effective use of the road network is achieved by ensuring that the infrastructure is safe and in a good state, stimulating a smooth traffic flow and reducing traffic jams as much as possible. Rijkswaterstaat is also responsible for the speedy and safe restoration of traffic circulation[4].

---

[2] Since then this handbook has been updated twice (US FHWA, 2000; US FHWA, 2010), so IM has a history of over 2 decades. The US traffic IM policy are stated in the 'National Unified Goals' (NUG): (1) Responder Safety, (2) Safe and Quick Clearance, and, (3) prompt, reliable and interoperable communications which are to implemented by 18 strategies (US FHWA, 2010).

[3] http://www.fema.gov/emergency/nims/

[4] Tuning and safeguarding the interests of all involved parties makes it possible to act satisfactorily on the basis of violating Article 5 which is concerned with endangering road safety. The Road Traffic Law (1994) lays down additional rules based on Article 2 of the Road Traffic Law (1881) or Wrongful act (Civil law book Article 6:162 BW and Rijksweg 12-arrest HR 19 December 1975, NJ 1976/280) against Rijkswaterstaat or infringement of title of ownership of Rijkswaterstaat as road owner. Removing damaged vehicles from incidents, stalled vehicles, and lost cargo (spilled loads) from roads is based on laws in the private domain as a result of a tort (Wrongful act) committed

IM in the Netherlands is primarily based on two basic regulations which have improved the organization of the salvage process. First, there is the national private car (NPR) regulation, whereby every private car in the Netherlands must have compulsory car insurance for primary post-accident recovery. The policy thus covers the costs (in kind) of the recovery of the vehicle at the scene of the incident, and its transfer to the first available safe location, such as a petrol-filling station or parking place. This means that, immediately after an accident, a salvage company can be called to remove the vehicle(s) from the main lane, instead of first calling the Police to investigate the situation. This saves not only time in dealing with an incident but also reduces the risk of subsequent accidents. This results in a reduction of handling time of 15 minutes (Feenstra *et al.*, 2002; Immers, 2007b). The second regulation, the National Truck Regulation (NTR), is similar to the NPR, but for trucks and lorries. The reduction in handling time is 60 to 90 minutes (Dutch Ministry of Transportation and Water Management, 1997). Many trucks in the Netherlands are not insured for primary post-accident emergency recovery. The main Dutch road authority (Rijkswaterstaat) guarantees the transport costs to a safe (working) spot[5].

In practice, there are a number of relevant laws, directives, and guidelines which have a direct or indirect relationship with the daily use of operational information systems. Examples are: the descriptive location identification system; the multidisciplinary questioning protocol; and incident evaluation. (see Dutch Ministry of Transportation and Water Management, 2003a, 2003b, 2004a). The Netherlands is one of the first European countries where IM regulations were established to create a solid basis to develop a professional IM organization and different specific IM measures.

3.3. Balance between policy and operation

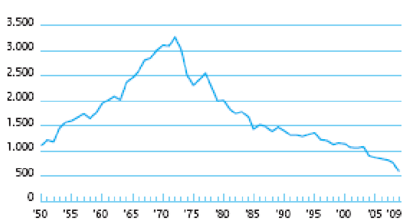
Before 1975 there were a limited number of highways, and traffic jams did not lead to major problems in terms of mobility and safety on a nationwide scale. Between 1975 and 1995 many new main roads were built, leading to a large increase in mobility, which in turn led to serious congestion problems. The issue of traffic jams caused by incidents then came high on the political agenda. Until that time, incidents were handled only by the Police (Dutch Ministry of Transportation and Water Management, 2010). In general, traffic becomes congested when the demand is greater than the supply. The ambition of the government, defined in the *Memorandum on Mobility* (Dutch Ministry of Transportation and Water Management, 2004b), is to provide reliable and smooth travel over the entire travel trip by 2020. IM is one of the main pillars of the dynamic traffic management programme that is applied to the Dutch road network. In the policy framework *Better utilization of existing infrastructure* (Dutch Ministry of Transportation and Water Management, 2008a), IM is regarded as one of the structural measures for a network-wide approach. Traffic incidents can have different effects at specific locations or times in the day. Therefore, in the Netherlands, a segment approach is currently been considered (Dutch Ministry of Transportation and Water Management, 2012).

---

against the road operator. This power is described in the Policy rules for Incident Management (Dutch Ministry of Transportation and Water Management, 1999) (Staatscourant 27 April 1999, No. 89 and amendments of 5 March 2003, 15 September 2004, and 19 November 2007).

[5] For this first initial recovery, the towing company nearest to the incident location will be used. In 2008 more than 4000 truck incidents took place (of which approx. 750 were accidents), with a monthly average of more than 330. In incidents involving trucks it tends to take some time before the main lane can be cleared for other traffic, thus causing traffic congestion.
A broken down vehicle which is left on the highway without any passengers can also be removed by the Road Authorities or the Police. The costs for towing are borne by the car owner. Similarly, there is a delayed and fast towing measure for trucks (Staatscourant 27 April 1999, No. 89 and amendments, 9 November 2007/ Nr. RWSCD BJV 2007/28228). *Delayed towing* is a first towing to remove the truck from the driving lane. The *fast towing* measure is a first towing where no special measures are taken to avoid the damage to the truck. These measures are taken when there is a hinderance to traffic flow and safety. The costs for these towing activities are borne by the Road Authorities (Dutch Ministry of Transportation and Water Management, 2008a). The *Initial Safety Measures for Incidents on Motorways for the emergency workers* defines how to secure an incident situation (Dutch Ministry of Transportation and Water Management, 2005b, renewed in 2011). This results in a lower probability of a secondary accident.

The cost-effectiveness of IM measures in terms of traffic flow, safety, and sustainability is high on the political agenda. Traffic organizations need to achieve a balance between (economic) benefits and investment in a broad range of traffic management measures. In the Netherlands, historically, there has been considerable experience with the implementation and evaluation of traffic management measures. Since the 1990s there has been a tendency to a shift from the building of new infrastructure to a better utilization of existing infrastructure. The results of this policy have become clearly visible for road users. Since 1970, this has involved the development and implementation of many traffic measures, such as traffic signalling, ramp metering, variable message signs, and specific IM measures.
Approximately 13 per cent of the traffic jams on Dutch roads are the result of incidents such as crashes and vehicles shedding their loads. The majority of these traffic jams are caused by incidents with cars (Dutch Ministry of Transportation and Water Management, 2004b). All these traffic jams contribute significantly to the economic damage. A traffic jam also creates an unsafe traffic situation, and in many cases collisions occur in the tail of the jam. This entails the risk of further material damage, as well as injury. Therefore, there is sufficient reason to limit, as far as is possible, the length and duration of such traffic jams. With the introduction of various measures (organizational and technical), it is possible to shorten the total incident duration and vehicle-loss hours. Since the introduction of IM in 1994, by 2004 there has been a reduction of 25 per cent in the average time of incident-related IM actions (Grontmij, 2004). Between 2004 and 2008 the incident duration decreased by another 10 per cent. The target is that, by 2015, the 2008 process time will be reduced by another 25 per cent (Dutch Ministry of Transportation and Water Management, 2008a).
At the beginning of the 1970s there were over 3000 fatal casualties (see Figure 2). By 2020 the Dutch government plans to reduce the number of fatal casualties to 500, and the number of injured to 10,600. In 2010 there were 640 fatal casualties, and approximately 17,000 injured. The goals are defined in the strategic plan *Traffic safety* (Dutch Ministry of Transportation and Water Management, 2008b) which includes an action programme, which describe the specific measures.



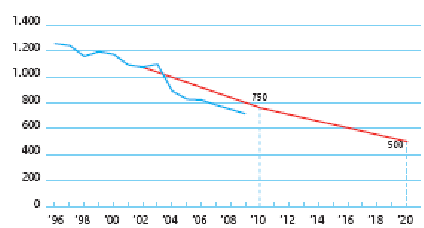


Figure 2a: Number of fatal casualties **Figure 2b: Policy goals related to fatal casualties**
Source: Dutch Ministry of Transportation and Water Management (2010).

3.4. Type and number of incidents: the problem of registration

On a yearly basis there are over 100,000 incidents (see Table 2: Leopold and Doornbos, 2009), varying from small accidents to major multi-vehicle incidents, causing casualties and damage to the road and its supporting structures. While relatively few incidents involve trucks, these incidents cause immediate, large-scale traffic jams that catch public attention. Because there are different organizations involved in the operational handling of IM, there are some difficulties in giving exact figures on IM. The main problem is the definition of different types of incidents. For example, for the nationwide Network Information System (NIS) of the Rijkswaterstaat (the Road Authority), there are four types of incidents: breakdown of vehicles; incidents with only material damage; those involving injured persons, death, fire, and dangerous goods; and investigation of guilt or crime[6]. Another aspect is the goal of registration. The traffic control centre is responsible for registering (logging) all the incident data to support the complete IM process. These registrations are basic input for all other off-line processes such as IM-evaluation and statistical accident registration. However, the Road Inspector is the main source for all relevant data, but his primary task is to clear the incident site as soon as possible. Registration is considered a secondary, low-priority task. The involvement of towing services is financially regulated in contracts, which gives another economic drive for good registration. Also data conversions from the regional traffic centre to the national Network Information System (NIS) cause some loss of data quality. Table 2b and 2c contains the incidents registered by towing services.

Table 2 (a): Number of incidents in the Netherlands

	Breakdown of vehicles		**Only material damage**		**Heavy accidents (injured, trucks)**		**Unknown**
number of incidents	61,287		12,926		1,720		24,681
percentage of total incidents	61%		13%		2%		24%
contribution to reduce incident time (1994-2008)	36% cars	22% trucks	26% cars	13% trucks	17% cars	10% trucks	-
mean contribution reduction time (1994-2008)	Approximately 30%						
contribution to reduce incident time (2004-2008)	13% cars	6% trucks	9% cars	3% trucks	5% cars	2% trucks	-
mean contribution reduction time (2004-2008)	approximately 10%						

Source: Leopold and Doornbos (2009).

Table 2 (b): Registered private cars

number of incidents with passenger cars	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
breakdown	1141	1912	3096	3582	4831	5893	11380	15847	22736	24558	33472
unknown	7471	5861	6098	6157	6047	6041	153	171	198	7399	123
accident	15832	18138	17661	18663	20798	20692	24366	25294	24465	20571	20160
Total	**24444**	**25911**	**26855**	**28402**	**31676**	**32626**	**35899**	**41312**	**47399**	**52528**	**53755**

[6] There are five Regional Traffic Management Centres, and each use their own registration and information systems, and also use different definitions of incident categories. Morever, not every incident (for example, a broken-down vehicle) is registered. The breakdown of vehicles on the hard shoulder, where there is a minimal and acceptable risk regarding the traffic flow and safety, is handled by the ANWB (Royal Dutch Automobile Association) without the involvement of the Road Inspector of the Rijkswaterstaat. The Police have their own classification.

Table 2 (c): Registered trucks

number of incidents with trucks	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
breakdown	440	639	771	948	1051	1204	1559	2057	2678	3008	3384
load	7	14	21	11	2	4		3	1		
unknown	6	5	8	38	8	16	10	4	20	12	39
accident	644	835	787	709	764	927	777	1034	1058	933	841
Total	**1097**	**1493**	**1587**	**1706**	**1825**	**2151**	**2346**	**3098**	**3757**	**3953**	**4364**

3.5. Economic costs of congestion and benefits

Recurring congestion occurs when normal traffic demand exceeds the physical capacity of the freeway. This congestion typically occurs due to systematic capacity shortages during high traffic volume periods (e.g. morning and afternoon peak periods), and is predictable in terms of its location, duration, time, and effect (Skabardonis *et al.*, 1997). Non-recurring congestion is the result of a short-term reduction in the capacity of a roadway (e.g. traffic incidents, work zones, special events etc). In the Netherlands, traffic accidents and delays are estimated to cost €10.4-13.6b/year of which delays alone cost €2.8-3.6b/year. Delays attributable to incidents amount to 12 per cent of this, i.e. €336-432m/year. IM is estimated to avoid €100-130M in social costs compared with an annual investment of €27m, implying a high Benefit/Cost Ratio (BCR) of between 4 and 5 (Leopold and Doornbos, 2009). The financial sacrifices of road usage in congested urban areas is indeed significant.

4. IM AS AN ACTOR-NETWORK APPROACH

IM in the Netherlands depends on cooperation between Rijkswaterstaat (the Dutch Road Authority) and other emergency response services. Together, they have set up new guidelines and protocols in order to shorten the time which is needed to clear the road after incidents. These guidelines are discussed and established in the National IM Platform. The cooperation between different organizations is clearly defined in Article 2 of the Policy Rules (Dutch Ministry of Transportation and Water Management, 1999). This was the initial start of the IM network which can be seen as a public-private partnership. To get a full picture of this network, we first look at how IM was introduced in different stages. Then we look in more detail at the actors, their role, and the legal mandate. Finally, we focus on how IM is becoming an information network.

4.1. IM development stages

Between 1995 and 2010, the development of IM in the Netherlands began to take shape, and was introduced in six different stages or time frames which partially overlap (see Figure 3, based on Zwaneveld *et al.*, 2000).

The '*orientation*' stage started at the end of the 1980s with an orientation on international IM activities. A number of to the USA, England, and Sweden confirmed and stimulated the ideas on IM in the Netherlands (Dutch Ministry of Transportation and Water Management, 1998, 2002, 2006, 2009). McKinsey and Company (1995) investigated the causes of congestion in the Netherlands. The audit revealed that the congestion caused by incidents was a significant proportion of the total. This stage ended in 1995 with the publication of an IM manual. (Dutch Ministry of Transportation and Water Management, 1995).

The '*pilot project*' stage started in 1994 and ended in 1997. Following the Action plan for implementing the recommendations from the report *Traffic jam poor road management* (McKinsey and Company, 1995), in 1996 and 1997 this resulted in the preparation of four pilot projects for national implementation. Several IM measures were tested on motorways around the cities of Utrecht, Rotterdam, and Amsterdam, which laid the basis for the national introduction of the Policy Rules for IM (Dutch Ministry of Transportation and Water Management, 1999).

The '*organization*' stage started during the previous stage, and ended in January 1997 with the foundation of the 'Project office for Incident Management'. Several emergency services are represented within this organization, e.g. the Police, Fire Brigade, transport authorities, motorway operators and insurance companies. The platform's task is to implement the national regulations and different IM measures. To this end, the platform has formulated agreements about the cooperation between the emergency services on motorways. Additional measures were prepared and initiated to accelerate the handling of the different IM phases (Dutch Ministry of Transportation and Water Management, 2005b). The '*implementation*' stage started in 1997, and consisted of the national introduction of IM measures. To limit the social damage that occurs when traffic jams form around incidents, in the late 1990s the Rijkswaterstaat signed a covenant with the Insurers' Association and the sector organizations. The Rijkswaterstaat is committed to implementing IM measures on the Dutch trunk road network. The aim of these IM measures is to ensure the safe and quick handling of incidents so that the traffic flow restrictions caused by an incident are lifted as quickly and safely as possible. It goes without saying that good victim assistance and the safety of both emergency service workers and other road users are important considerations.

The '*professionalization*' stage was created with the establishment of the IM Consultation in 2008 and the reports *Guide to professional IM* (Immers, 2007a, b) and *Smart goals for IM* (Immers and Landman, 2008). This phase is characterized by the increasingly close cooperation of partners and the sharper demarcation of responsibilities and powers.

Currently, we are in the '*integration*' phase which is characterized by increased road use, higher expectations of road users, and high ambitions in terms of traffic flows and safety. This is closely linked to financial cuts in IM services and a slow retreat of the role of the police in IM tasks that make it necessary for all parties to work together even more closely with an emphasis on better communication and information sharing.

Since the start of the professionalization and integration phases, information-sharing between the emergency services involved has become increasingly important for a quick and appropriate response. These efforts have a direct correlation with public safety and mobility. Information-sharing allows multiple agencies to identify the necessary resources and provide coordinated traffic IM. It also provides the motoring public with information upon which to base their travel choices. With the introduction of various measures (organizational and technical) it seemed to be possible to shorten the total incident duration and lost vehicle-hours. However, it is important to realize that the public and private IM actors involved have their own specific task and legal responsibility. This is an important constraint to develop new information architectures and systems to improve collaboration between different IM chain members.

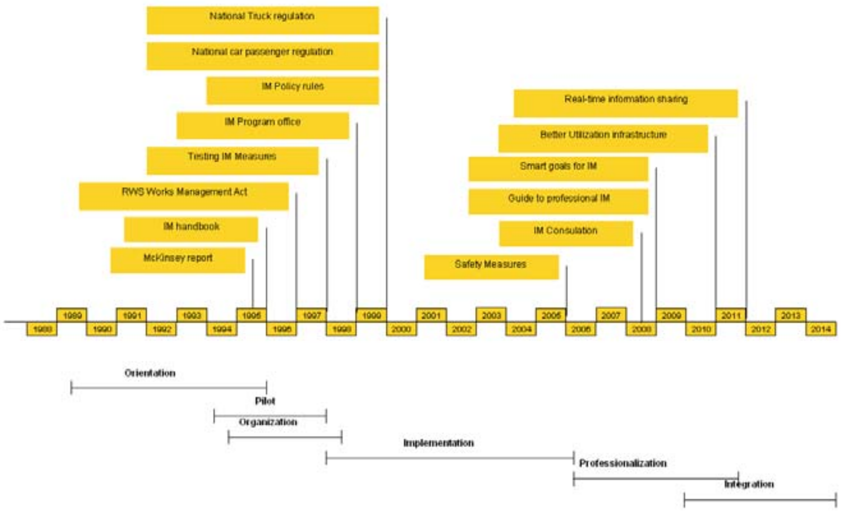


Figure 3: IM development stages in the Netherlands

4.2. Public IM actors

The public IM emergency services are the Road Authority, Police, Fire Brigade, and the Ambulance services. The Rijkswaterstaat has, in the context of the law the Rijkswaterstaatworks Management Act (1996), the public responsibility for the efficient and safe use of the main road network[7].

The Dutch Police Law (1993) makes the Police responsible for settling the incident. Most incidents on the highways are reported by the 112 emergency lines coming in to the control room of the Police. They will inform the surveillance units of the Police and, if necessary the Fire Department Control Centre, the Ambulance Dispatch Centre and the regional traffic centre. The Police coordinate the effective handling of the incident with the other emergency services. In the case of disasters, this responsibility shifts to the Fire Department and Municipality. The handling of IM by the Police is based on the Dutch Road Traffic Law (1994). Under Article 2 of the Police Law, the police have the legal responsibility to support public transportation with IM-related tasks, in terms of road safety and towing services.

The activities of the Fire Brigade are based on the Dutch Fire Brigade Law (1985) and the Dutch Municipality Law (1992). Their primary tasks are ministering first aid to road victims, removing victims from crashed (damaged) cars, and avoiding or reducing the release of toxic or dangerous substances. The Ambulance team makes an estimate of the magnitude of the injured, determines which victims need first aid, and handles life-threatening situations based on the Dutch Law on Medical Aid in Accidents and Disasters (WGHOR, 1991). In cooperation with the Fire Brigade it assists in removing victims from damaged vehicles. In 2010 the legal basis of the Police, Fire Brigade and Ambulance was replaced by the Dutch Law on Safety Regions (2010). Private actors also play an important role in the daily handling of traffic IM. Hence, information systems need to have clearly defined interfaces to share public-private information.

4.3. Private IM actors

Towing, repair, and insurance services are the main tasks of private IM parties. To structure these activities on a nationwide scale, different foundations have been formed. Salvage help

[7] In the Netherlands, there is one National Traffic Management Centre for the coordination of major incidents. For the daily operational tasks, there are five Regional Traffic Management Centres, from which traffic management measures can be taken for the entire road network. These centres are managed by the Rijkswaterstaat, and are in close contact with the Central Dispatch Centre of the National Police (KLPD), the control rooms of the Regional Police and other emergency services (Dutch Ministry of Transportation and Water Management, 2000). The Netherlands Traffic Centre (VCNL)'s main objective is to stimulate a safe traffic flow, and provide reliable travel information.

after an incident is a private matter between the insurer and the driver of the vehicle, arranged through an insurance policy. Insurers have assigned the execution of this service to Alarm Control Centres.

The Netherlands Incident Management Foundation (SIMN) is responsible for the towing of passenger vehicles (Gross Vehicle weight of <3500 kg) on the major roads in the Netherlands. The Foundation was established to provide support to the Road Authorities for their efforts in the area of IM. In the Netherlands, passenger cars need at least liability insurance. In this liability insurance coverage, a fee is included for initial emergency towing services, after an accident, to a safe location, such as a gas station or a parking lot. Towing aid is a private matter. The insurers have assigned this task to the call centres. The Foundation ensures the involvement of individual companies. This operational role is fulfilled by exploiting what is called the National Central Hotline (LCM)[8].

The Lorry Incident Management Foundation (STIMVA) is responsible for the central coordination of the use of towing services and equipment. In practice, this is a cooperation between insurance companies, the Dutch branch organization for Transport and Logistics, their own transport organization, the Royal Dutch Transport Organization (KNV), and the Rijkswaterstaat[9].

The Lorry Salvage Consultant (STI) is a cooperation between the Dutch fire insurance companies, expertise bureaus, and cleaning reconditioning companies. All salvage message are handled directly from the Fire Department to the international Insurance Aid Service (VHD-group). The primary goal is to minimize the direct and indirect claims, by respecting the needs of the insured at the time. The VHD-group provides assistance for medical treatment and has financial responsibility as a central organization for governments. The Royal Dutch Automobile Association (ANWB) operates emergency car-repair and towing services for broken-down vehicles.

4.4. The IM information chain

There are many private and public organizations involved in the daily handling of IM. These have their own tasks and legal responsibility (see Table 3). IM organizations are strongly related and need to collaborate for an effective incident response. Each organization has the same kind of problems in terms of system diversity, architecture, and standards used. Information-sharing between traffic management control centres, emergency control centres, towing services and insurance companies is becoming increasingly important. To have identical situational awareness and a common handling framework for effective IM is necessary for the further improvement of cooperation.

---

[8] The LCM acts as a central sharing point for incoming incident reports on the part of the Police and Road Authorities. Each message received by the LCM, is translated into a mission for a towing company which has a contract with the Foundation.

[9] The STIMVA provides the use of salvage companies for trucks (Gross Vehicle weight > 3500 kg). This operational role is fulfilled by exploiting what is called the Central Service Desk for Truck Accidents (CMV). Application of the usual method of disposal trucks often requires the careful use of advanced equipment, and the application of prescribed procedures for storage as safely and quickly as possible. In this way, the chance of damage to vehicles, cargo, and the roads is as small as possible. After that, the truck is towed to a safe place. This recovery process is usually time-consuming, and causes significant delays for traffic on the network. The handling costs of recovering and towing of breakdown trucks are borne by the vehicle owner, regardless of the location of the incident.

Table 3: Overview of IM organizations and their roles

Organization	Public	Private	Mobility	(Road) safety	Question of Guilt	Medical Aid	Insurance	Towing Repair
Road Authority (Rijkswaterstaat) - Regional Traffic Control Centre (RVMC) - Road Inspector	**X**		**X**	**X**				
Police - Police Control Centre - Police officer	**X**		**X**	**X**	**X**			
Fire Brigade - Fire Control Centre - Firemen	**X**			**X**				
Medical services (GHOR) - Ambulance Dispatch Centre - Ambulance men	**X**			**X**		**X**		
Netherlands IM Foundation (SIMN) - IM Recovery Dispatch Centre (LCM)		**X**		**X**			**X**	**X**
Lorry IM Foundation (STIMVA) - IM Lorry Recovery Dispatch Centre (CMV)		**X**		**X**			**X**	**X**
Recovery (towing) Service Company		**X**		**X**				**X**
VHD-group		**X**		**X**			**X**	
Lorry Salvage Consultant (STI)		**X**		**X**				**X**
ANWB		**X**		**X**				**X**

Timely and accurate information plays an important role in the information chain between all the IM emergency services. The increasing importance of information is clearly visible from a historical perspective, which shows how traffic IM was introduced in different stages. Inter-agency exchange of information is the key to obtaining the most rapid, efficient, and appropriate response to highway incidents from all agencies. Information systems play an important role within and between organizations. A distinction can be made between the different activities (see Table 4).

Table 4: Activities to support traffic IM within and between organizations (Based on CEDR, 2011)

<table>
<tr><th>Within an organization</th><th>Between organizations (Cooperation)</th></tr>
<tr><td>Command</td><td rowspan="2">Coordination</td></tr>
<tr><td>Control</td></tr>
<tr><td colspan="2">Communication</td></tr>
<tr><td colspan="2">Information</td></tr>
</table>

‘Command’ means the authority for an organization to direct the actions of its own resources. The CEDR (2011c) report acknowledges that local scene commanders will determine the deployment of resources to the scene of traffic incidents. ‘Control’ means the authority to direct strategic and tactical operations in order to complete an assigned function. It includes the ability to direct the activities of other agencies engaged in the completion of that function. The control of an assigned function also carries with it a responsibility for the health and safety of those involved. ‘Cooperation’ is working together to achieve a common aim. ‘Coordination’ is the harmonious integration of the resources, expertise, and activities of partner organizations, with the objective of effectively and efficiently resolving the incident. ‘Communication’ is the timely exchange of ‘information’ within and between organizations. Developments in information, communication and sensor technology can provide new concepts and possibilities. The increasing number of incidents and the related economic problems are forcing IM organizations to improve their cooperation on many levels, particulary with respect to information sharing in urban agglomerations.

5. ASSESSMENT OF CRITICAL SUCCESS FACTORS OF URBAN TRAFFIC IM

Traffic IM is apparently a sine qua non for the smooth operation of infrastructure in urban areas. It is a complex undertaking that needs to be reviewed regularly, with the aim to identify critical success conditions for effective traffic IM. In our analyses of the current status of traffic IM deployment, we used an Internet questionnaire administered to the relevant stakeholders. The main goals of this research are to get a clear and critical overview of the main information, communication, and coordination issues; to gain knowledge of the main information needs of each IM organization; and to see what is the information dependency from an actor-network approach. The respondents to this questionnaire are the Rijkswaterstaat (in particular VCNL as the National Traffic Management Centres and five regional traffic management centres), the Safety regions (Police, Fire Brigade and Ambulance), the towing services (LCM and CMV), and the Royal Dutch Automobile Association (ANWB) (see also Table 5).

Table 5: Results of the survey questionnaire

		Frequency	**Percentage**	**Valid percentage**	**Cumulative percentage**
Valid	Police	74	25.7	31.4	31.4
	Fire Brigade	41	14.2	17.4	48.7
	Ambulance (GHOR)	34	11.8	14.4	63.1
	ANWB	4	1.4	1.7	64.8
	RWS (RTMC)	52	18.1	22.0	86.9
	RWS (VCNL)	9	3.1	3.8	90.7
	Towing (LCM)	11	3.8	4.7	95.3
	Towing (CMV)	11	3.8	4.7	100.0
	Total	**236**	**81.9**	**100.0**	
Missing		52	18.1		
Total		**288**	**100.0**		

5.1. Information, communication and coordination problems

Figure 4 describes the main information problems during the incident notification. Problems are, in general, issues which delay or confuse the effective handling of an incident. We made a distinction between nine categories. The safety regions (Police, Fire Brigade and Ambulance) give approximately the same picture. The Ambulance services has most problems with respect to receiving the wrong number of involved casualties. The main problems for the Police and Fire Brigade are false incident notifications. The towing services main problems are also false incident notifications, and the LCM regularly faces having the wrong number of involved vehicles. The ANWB is sometimes not informed about an incident. The Regional Traffic Management's Central main issues concern the wrong incident location and the wrong number of involved vehicles.

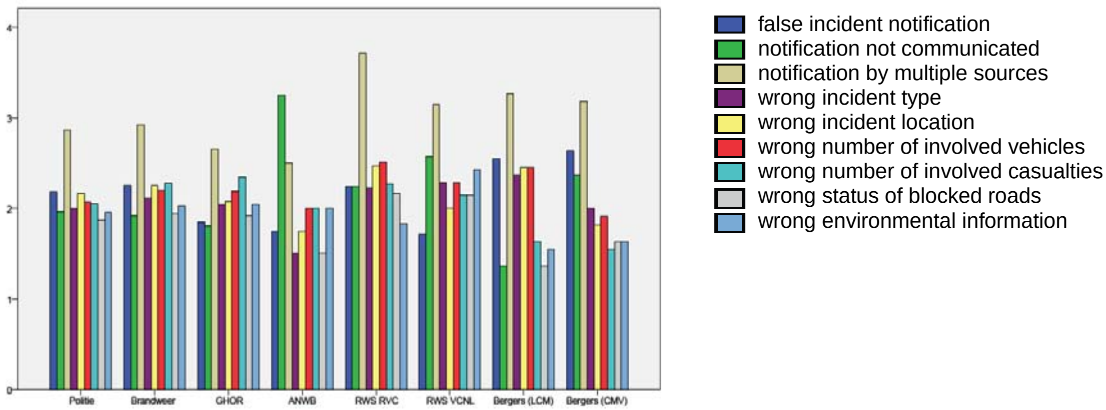


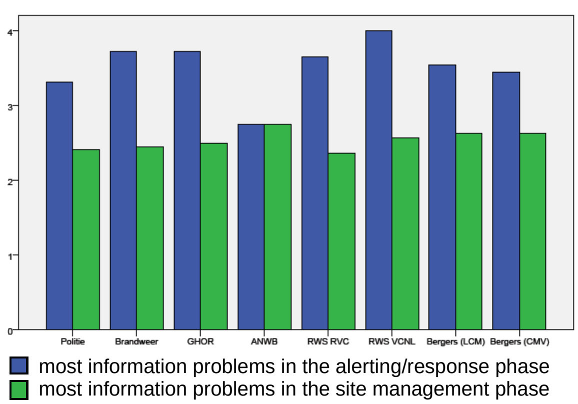
Figure 4: Incident information notification issues.

Note*: 1 = never; 2 = sometimes; 3 = regularly; 4 = often; 5 = very often.*

Note: Politie = Police; Brandweer = Fire Brigade; GHOR = Ambulance services; ANWB = The Royal Dutch Automobile Association; RWS RVC = Rijkswaterstaat Regional Traffic Management Centre; RWS VCNL = Rijkswaterstaat National Traffic Management Centre; Bergers LCM = Towing Central Service Desk for Car Accidents; Bergers CMV = Towing Central Service Desk for Truck Accidents.

There is a strong (quadratic) relationship between the duration of an incident and the response time required from the Traffic Management Centre and the emergency services (Steenbruggen *et al.*, 2012). The early and reliable detection and verification of incidents, together with integrated traffic management strategies, are important contributions which can improve the efficiency of the incident response. Figure 5a indicates in which phase IM organizations have the most information problems. Here, it is clearly visible that the most problems occur in the first phases of the incident.

Also the coordination of IM measures plays an important role for effective IM handling. Figure 5 shows that organizations do not have a good overview of the activities of the other organizations. It is clear that these two aspects need some improvements in the cooperation between emergency services.



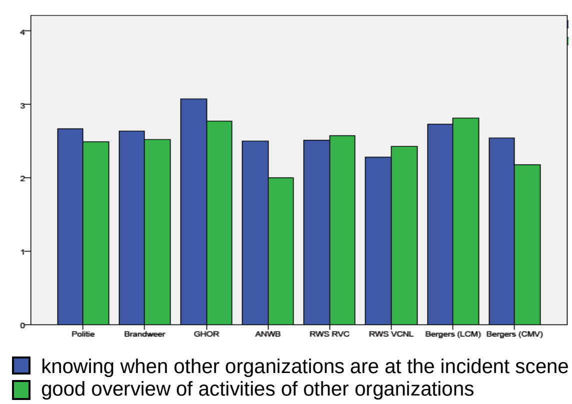


Figure 5a: Information problems per phase **5b: Coordination problems**

Note: 1 = *strongly disagree*, 2 = *disagree*, 3 = *neutral*, 4 = *agree*, 5 = *strongly agree.*

5.2. Information needs

The second part of the questionnaire was designed to see what specific information is necessary to support a traffic IM information system. We made a distinction between three categories: incident; surrounding environment; and organization information. Figure 6 gives an overview per organization.

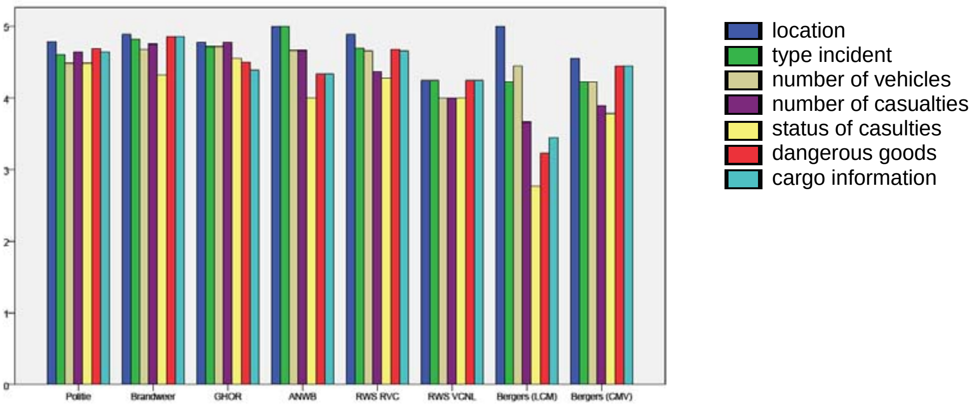


Figure 6: Information needs about the incident

Note: 1 = *strongly disagree*, 2 = *disagree*, 3 = *neutral*, 4 = *agree*, 5 = *strongly agree.*

In the guideline, First Safety Measure for incidents on the highways there is a clear list of priorities for the handling of traffic incidents. These are the safety of the emergency workers, primary aid for the victims, smooth traffic flow, and control of infrastructure. In order of importance, safety has a higher priority then smooth traffic flow. It is however, surprising to see that the safety and status of potential victims scores lower than the other information categories. The Ambulance (GHOR) score is clearly higher than that of the other organizations. Location information has the highest score. Also cargo information and dangerous goods have a high priority, with the exception of the LCM. Nearly all the items score between 4 and 5. This indicates that information about the incident has a high priority. The need for environmental information is divided into nine categories (Figure 7). Here, is clearly more variety in the scores. Information about blocked lanes is scored high by the Regional Traffic Management Centre and VCNL. The status of blocked roads and the best driving route to the incident scene scored high for all organizations. The Ambulance services (GHOR) and LCM are less interested in environmental damage. This group is considered as important but scores significantly lower than information about the incident.

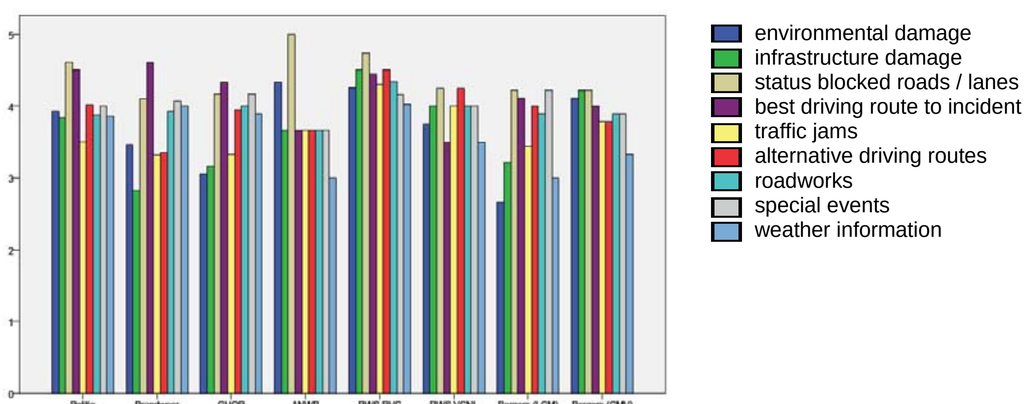


Figure 7: Information needs

Note: 1 = *strongly disagree*, 2 = *disagree*, 3 = *neutral*, 4 = *agree*, 5 = *strongly agree.*

The third group is organization information. It is remarkable that these information needs score approximate equally for all organization with exception of the LCM. The need for organization information is at approximately the same level as environmental information. Within the safety regions (Police, Fire Brigade and Ambulance) this functionality to view the status and location of fieldworkers of other organizations already exists. For the Rijkswaterstaat, ANWB, LCM and CMV this functionality does not yet exist. This could clearly improve the cooperation between emergency organizations.

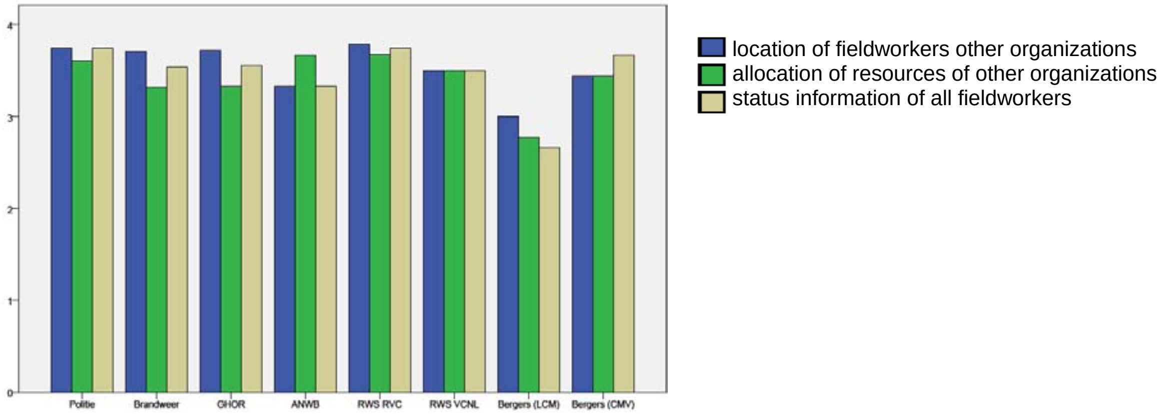


Figure 8: Information needs
Note: 1 = *strongly disagree*, 2 = *disagree*, 3 = *neutral*, 4 = *agree*, 5 = *strongly agree.*

5.3. Information dependency

The collaboration between emergency organizations is clearly described in Article 2 of the Policy Rules (Dutch Ministry of Transportation and Water Management, 1999). This was initially the start of the IM actor network of different public and private organizations on the national and the regional level. In these policy rules there is some general agreement on how to cooperate for effective IM handling. This includes specific measurements on organization, communication, cooperation, and responsibilities. This is necessary because each organization has its specific role and legal responsibility.
To understand the network operation it is important to understand the inter-organizational strength in terms of information dependency. Table 6 indicates how each organization scores its information dependency on other organizations: in other words, how dependent organizations are on information from other organizations in order to be able to effectively handle an incident.
From this table it is clear that various organizations are most dependent on the Rijkswaterstaat and the Police. In second place, we find the Fire Brigade and the Ambulance services and then the towing and repair services. We did not distinguish between different types of incidents. In addiction, we can see that the CMV (trucks) is more dependent on the Fire Brigade and the Ambulance than LCM is while LCM has a stronger relation with the ANWB than CMV does. The Fire Brigade and the Ambulance service results indicate that they are less dependent on the towing services.

Table 6: Information dependency on other organizations

	RWS	Police	Fire Brigade	Ambulance	ANWB	Towing
RWS (RTMC)	4.26	4.21	4.00	3.77	3.60	3.81
RWS (VCNL)	4.50	3.75	3.00	2.75	3.00	3.75
Police	3.71	3.94	3.45	3.49	2.76	2.71
Fire brigade	3.71	4.07	4.11	4.11	2.32	2.18
Ambulance	2.94	4.06	3.89	4.00	2.56	1.89
ANWB	4.33	3.33	3.00	3.00	4.33	3.33
Towing (LCM)	4.27	4.00	1.82	1.82	3.55	3.64
Towing (CMV)	4.00	3.78	2.67	2.67	2.78	3.89
Total	**3.85**	**4.02**	**3.58**	**3.54**	**2.97**	**2.98**

In Table 7 we asked how the actors' own information is relevant for other IM organizations. The Rijkswaterstaat, the Police and the ANWB all indicate that they believe that they are strong information provider, for other organizations. This is in line with Table 6, with the exception of the ANWB.

Table 7: Own information that is valuable for other organizations

	RWS	Police	Fire Brigade	Ambulance	ANWB	Towing	Total
RWS (RTMC)	4.33	4.21	4.14	4.05	3.58	4.30	**4.10**
RWS (VCNL)	4.50	3.25	3.00	2.75	4.25	2.50	**3.38**
Police	4.22	4.20	4.04	4.00	3.20	4.00	**3.94**
Fire brigade	3.57	4.00	4.04	4.04	2.68	3.00	**3.56**
Ambulance	2.94	3.89	3.83	3.89	2.44	2.17	**3.19**
ANWB	4.67	4.00	4.00	4.00	4.67	4.00	**4.22**
Towing (LCM)	3.45	3.00	2.36	2.36	2.82	4.36	**3.06**
Towing (CMV)	3.67	3.56	2.78	2.78	2.89	4.22	**3.32**

Finally, in Table 8 we compare the results from Table 6 to see how organizations score each other. This is interesting because this defines the interdependency of the organizations involved. This defines the strength of the individual relation in terms of information dependency. The cells shaded in green indicate, for each of the organizations in Column 1, what are the organizations on which they most depend. The main IM organizations for the Traffic Management Centre are the Police, Fire Brigade and the Ambulance service. The towing and repair services score a little lower. The National Traffic Management Centre sees the Police as its most important player.

The Police are seen as the strongest information organization. This can be explained historically, because originally they also had the responsibility for traffic management. In recent years, this role has slowly been handed over to the Traffic Management Centre. The Fire Brigade is strongly related to the Police and the Ambulance services. The Police is the most important player for the Ambulance services. The ANWB sees all players as important. LCM's main players are the Rijkswaterstaat, the Police and the ANWB. CMV has a strong relationship with the Rijkswaterstaat, the Police, the Fire Brigade and the Ambulance services. This provides a good guidance for developing new information systems to support traffic IM.

Table 8: Interdependency of information between organizations

	RWS	Police	Fire Brigade	Ambulance	ANWB	Towing
RWS (RTMC)	-	1.13	1.08	1.28	0.83	0.92
RWS (VCNL)	-	1.01	0.81	0.94	0.69	0.94
Police	0.88	-	0.85	0.86	0.83	0.69
Fire Brigade	0.93	1.18	-	1.06	0.77	1.00
Ambulance	0.78	1.16	0.95	-	0.85	0.87
ANWB	1.20	1.21	1.29	1.17	-	1.00
Towing (LCM)	1.12	1.48	0.83	0.96	1.07	-
Towing (CMV)	1.05	1.39	1.22	1.41	0.83	-

Note 1: In the first column only the Regional Traffic Management Centre is included.
Note 2: In the last column the mean value of the towing services (LCM and CMV) is presented.

6. NEW CONCEPTS IN INFORMATION SHARING

The introduction of new data sets and information concepts can be helpful in solving the identified problems and in reducing the time interval between the detection of the incident and the re-establishment of traffic flows in a significant way. This is particulary the case when information systems are linked to the information needs of the actors involved in the IM process. Almost all the information needs to have a geographical component (Grothe *et al.*, 2005). The main goal is to improve the Situational Awareness of the emergency services. Therefore, we can use the three-level model of Endsley (1995). For typical questions related to traffic IM, we refer to Table 9. These information needs should be combined in a '*situation report*' (Sitrap) or a '*Common Operational Picture*' (COP).

Table 9: Levels of Situational Awareness and spatial IM information needs

Situational Awareness	Information questions
a person's perception of elements in the environment within a volume of time and space	• Incident location – where, extent? • Who is where? • Where are the incident managers / emergency services? • Where is congestion located; where are the traffic jams? • Where are the road users?
the comprehension of their meaning	• What is the nature of the event? • How should we respond? • What are they doing? • What causes congestion: incidents, events, weather? • What is the accessibility of the incident site for the emergency services? • How many people are in the area? • Which traffic management strategies do I have at my disposal?
the projection of their near future	• What will they do? (activity) • At what time will they be (t)here • How far do the consequences of an incident reverberate on the road network? • What risks are there for the surrounding area (e.g. chemical releases)?

Source: Endsley (1995)

This intelligence can be better handled with the introduction of new information systems based on ‘net-centric’ peer-to-peer solutions which offer new possibilities for cooperation in terms of information, communication, and coordination (Steenbruggen *et al.*, 2012). A COP supports operational activities on the lowest GRIP level 0. Incidents or disasters on higher GRIP levels are more based on a Common Strategic Picture (CSP) to support managers and policy makers. Both pictures need to contain spatial information (Scholten and van der Vlist, 2011). Effective communication both within and between the emergency services is essential for the common appreciation of the situation, and rapid and unambiguous decision making, together with command and control, and the coordinated deployment of resources necessary to achieve an agreed outcome (UK HWA, 2009).

7. DISCUSSION

At its core, IM is a vehicular traffic-support system, originally intended to clear traffic incidents as quickly as possible, but its implementation in practice has always taken the functionality further, to include any activity to support the most efficient movement of traffic, regardless of the circumstances. As such, a large number of agencies and people are involved in its implementation, its uses, and its consequences. This organically-grown and extended IM is a systematic, planned, and coordinated effort to prevent, detect, respond to, and remove any incident, or remedy any condition that hinders optimal traffic flow, spanning all agencies and other concerned organizations and individuals that have a stake in its effectiveness. Much of what is needed is already available. Each of the communities mentioned above has been or is working on its own private optimizations, data structures, communication protocols, procedures and knowledge-base, both theoretical and practical. Each group operates as a team, trying to optimize its own part of the world. However, the optimal position for each group separately will not automatically produce a system-wide optimal position. The reason is the synergetic behaviour of the components of such complex systems. If we are concerned only about clearing incidents, but not about improving the everyday performance of the transportation network, then we are missing the larger savings (systems pay-back) possible from improvements in the entire system.

The use of location methods and the sharing of spatial information is currently limited. A typical location report will consist of a road number, and a direction and distance marker number, which is considered to be ambiguous. Furthermore, it reflects the current practice in which IM is limited to highways. On secondary roads, road markers may not always be present. Noting a location by (secondary) road number will only give the emergency services an indication of where the accident has taken place. Using geo-spatial information can not only speed up an event in IM but also provide a cheaper alternative to current methods. However, before considering the service, the data sets and infrastructure have to be addressed. The current situation in IM clearly does not satisfactorily address new technologies or interoperability between systems. While there can be an argument about privacy issues, this is a matter for policy not technology.

Since the 1990s, ITS in the Netherlands has been based on cooperation between the government and the private sector. ITS Netherlands was founded as a public-private institution in 1996. Traffic IM is one of the main priorities in the Netherlands in terms of creating ITS tools in the several steps involved in this process, including: incident detection (e.g. with cameras and e-Call); communication between emergency services; and the provision of traffic information to the end-user. In terms of ITS standards, the Netherlands actively participates in existing global and European standardization platforms such as ETSI, CEN and ISO. An overview of the ITS-related initiatives in the Netherlands, based on Directive 2010/40/EC, can be found in the document *ITS in the Netherlands* (Connect, 2011). DATEX2, for example, is used in information-sharing in the national road database (NDW) for traffic management, but is not used to share incident information between responders. Currently, within crisis management, the safety regions are implementing the National Crisis Management System (LCMS - Landelijk Crisis Management Systeem), which is based on a net-centric approach. However, this system only supports large-scale disasters, and not daily traffic IM and does not have a direct relationship with traffic management. From the geo-information sector, GEONOVEM is currently working on an information model on homeland security (IMOOV). This provides the definition of information elements (semantic) and the exchange platform (UML and XML), which is basically the implementation of a Service Oriented Architecture (SOA). The Netherlands is the first EU country which has tried to develop a COP for IM based on a net-centric approach to improve Situational Awareness. This is a challenging task when there is a lack of concepts, architecture, and standards. However, this can set the scene for future developments in the EU. The following general conclusions can be drawn:

- In an urbanized Europe with a dense transportation network, the professional development of IM technology is a prerequisite for sustainable urban and transportation strategies.
- Since the 1970s there have been an increasing number of incidents on the European roads. In the Netherlands there are approximately 270 incidents a day, which are an increasing cause of traffic jams, congestion and vehicle lost-hours.
- National governments have limited possibilities to enforce strict rules regarding IM because of the large number of involved organizations and the many laws that (in-) directly deal with IM. However, legal aspects and the political context have become increasingly important for accomplishing interoperability.
- Almost all IM-related information has a spatial component to improve Situational Awareness.
- More public and private actors are getting involved, which has led to the IM information network.
- Net-centric information services are seen as an important instrument to improve cooperation.

REFERENCES

Calabrese, F., Kloeckl, K. and Ratti, C. (2007). WIKICITY: Real-time urban environments. *Pervasive Computing, Mobile and Ubiquitous Systems* Vol. (6)3, pp 52-53. July - September 2007.

Calabrese, F., Colonna, M., Lovisolo, P., Parata, D. and Ratti, C. (2011). Real-Time Urban Monitoring Using Cell Phones : A Case Study in Rome. IEEE Transactions on Intelligent Transportation Systems (2011). Volume: 12, Issue: 1, Publisher: IEEE, Pages: 141-151.

Carrillo, F. J. (2006). Knowledge Cities, Oxford, Elsevier Inc.

Corbin, J. and Noyes, P.B. (2003). Traffic Incident Management Planning: The Case for Mainstreaming. ITE Journal, February 2003. Available online: http://www.findarticles.com/p/articles/mi_qa3734/is_200302/ai_n9211940

Conference of European Directors of Roads – CEDR (2011). Best Practice in European Traffic Incident Management. Final Report of Task 13, March 2011.

Connect (2011). ITS in the Netherlands, In opdracht van het Ministerie van Infrastructuur en Milieu.

Downey, J. and McGuigan, J. (1999). *Technocities,* London, SAGE Publications Ltd.

Dutch Civil lawbook (1881). Article 162, see: http://www.wetboek-online.nl/wet/BW6/162.html

Dutch Fire Brigade law (1985). see: http://www.st-ab.nl/wetten/0052_Brandweerwet_1985.htm

Dutch Law on Medical Aid on Accidents and Disasters (1991). Wet geneeskundige hulpverlening bij ongevallen en rampen.

Dutch Ministry of Transportation and Water Management (1995). Handleiding Incident Management, Adviesdienst Verkeer en Vervoer (1995) (Eng: Manual Incident Management), Ministerie van Verkeer en Waterstaat, Rotterdam, Nederland. in Dutch.

Dutch Ministry of Transportation and Water Management (1997). Incident Management, Vrachtautoberging. VCNL Projectbureau IM, 1997.

Dutch Ministry of Transportation and Water Management (1998). Incident Management, Putting people together, verslag van een studiereis naar de U.S.A., November 1998.

Dutch Ministry of Transportation and Water Management (1999). Policy Rules Incident Management Rijkswaterstaat Netherlands.

Dutch Ministry of Transportation and Water Management (2000). Verkeerskunde en Verkeersbeheersing, Rapport DVM98.64040101.14.

Dutch Ministry of Transportation and Water Management (2002). See your taxdollars at work. Verslag studiereis naar de USA, VCNL September 2002.

Dutch Ministry of Transportation and Water Management (2003a). Richtlijn Beschrijvende Plaatsaanduiding Systematiek (BPS). 2003/HKW/2003/VCNL/8393, 26 November 2003.

Dutch Ministry of Transportation and Water Management (2003b). Voorlopige richtlijn multidisciplinair uitvragen incidenten auto-snelwegen. Mei 2003, Commentaarversie 1.0. Verkeerscentrum Nederland, Utrecht.

Dutch Ministry of Transportation and Water Management (2004a). Richtlijn voor incident evaluaties. Grontmij Advies & Techniek bv, Verkeer & Infrastructuur, De Bilt, V&I-99343184/CS, rev. 0, 20 Februari 2004.

Dutch Ministry of Transportation and Water Management (2004b). Memorandum on Mobility – Towards a reliable and predictable access, Ministry of Transport, Public works and Water Management, 30 September 2004.

Dutch Ministry of Transportation and Water Management (2005a). Red blue booklet, the Roles of Emergency Services in Incident Management in the Netherlands. ISBN 90-369-0097-2 April 2005.

Dutch Ministry of Transportation and Water Management (2005b). Directive Initial Safety Measures for Incidents on Motorways in the Netherlands. Verkeerscentrum Nederland, 2005.

Dutch Ministry of Transportation and Water Management (2006). Studiereis Incident Management naar de USA, VCNL.

Dutch Ministry of Transportation and Water Management (2007). Inventarisatie beleidseffecten incidentmanagement. Rijkswaterstaat Adviesdienst Verkeer en Vervoer, 2007, in Dutch (English summary).

Dutch Ministry of Transportation and Water Management (2008a). Beleidskader Benutten. Eén van de pijlers voor een betere bereikbaarheid. Ministerie van Verkeer en Waterstaat, Januari 2008.

Dutch Ministry of Transportation and Water Management (2008b). Strategische plan Verkeersveiligheid 2008 – 2020. Van, voor en door iedereen. Mei 2008.

Dutch Ministry of Transportation and Water Management (2009).Verslag studiereis Incident Management naar Engeland (Lees) en Zweden (Stockholm), Ministerie van Verkeer en Waterstaat, Rijkswaterstaat, Oktober 2009.

Dutch Ministry of Transportation and Water Management (2010). Kerncijfers Verkeersveiligheid.

Dutch Ministry of Transportation and Water Management (2012). Positioning Paper Incident Management. Ministerie van Verkeer en Waterstaat, Steenbruggen, J. September 2012.

Dutch Municipality Law (1992). see: http://www.st-ab.nl/wetten/0093_Gemeentewet_Gemw.htm

Dutch Police Law (1993). see: http://www.st-ab.nl/wetten/0237_Politiewet_1993_PolW.htm

Dutch Road Traffic Law (1994). see: http://www.st-ab.nl/wetten/0352_Wegenverkeerswet_1994_Wvw_1994.htm

Dutch Safety region Law (2010). Wet van 11 februari 2010, houdende bepalingen over de brandweerzorg, de rampenbestrijding, de crisisbeheersing en de geneeskundige hulpverlening (Wet veiligheidsregio's). Staatsblad 2010, nr. 145.

Dutton, W. H. 1987. *Wired Cities: Shaping the Future of Communications,* London, Macmillan.

EasyWay (2011). Traffic Management Services, Guidelines for the deployment of Incident Warning and Management. Core European ITS Services and Actions, TMS-DG05-08, Draft version 0.9, September, 2011.

ECMT (2007). European Conference of Ministers of Transport (2007). Managing Urban Traffic Congestion. Organization for Economic Co-operation and Development (OECD), Transport Research Center ISBN 978-92-821-0128-5.

Endsley, M.R. (1995). Toward a Theory of Situation Awareness in Dynamic Systems. *Human Factors*, 37(1), pp. 32-64.

Eppler, M. (2003). Managing Information Quality. Increasing the Value of Information in knowledge-intensive Products and Processes, Berlin: Springer.

European Transport Safety Council (2011). Traffic Law Enforcement across the EU Tackling the Three Main Killers on Europe's Roads.

Evans, J.R. and Lindsay, W.M. (2005). *The management and control of quality*. 6th ed. Cincinnati, OH: South-Western/Thomson Learning.

Feenstra, N., R.C. Krommenhoek, J.H. Leopold, M.A. Loos, and R.C.v.d. Mark (2002). Landelijke evaluatie Incident Management. Berenschot, 2002.

Federal Emergency Management Agency - FEMA (1998). Introduction to Mitigation Independent Study Course. IS 393. USA, 1998.
Florida, R. (2005). *Cities and the Creative Class,* New York, Harper Business.
Grontmij (2004). Richtlijn voor incident evaluaties. De Bilt: Grontmij Advies & Techniek B.V.
Grothe, J.M., Landa, H.C. and Steenbruggen, J.G.M. (2005). *The Value of Gi4DM for Transport and Water Management*. in: Geo-information for Disaster Management (Eds. Oosterom, P. van and Fendle, E.M.), ISBN 3-540-24988-5. Springer Berlin Heidelberg, New York.
Hollands, R. G. (2008). Will the real smart city please stand up. *City,* 12.
Immers, L.H. (2007a). Guide to professional Incident Management, TNO-rapport 2007-D-R1242/B Wegwijzer naar professioneel Incident Management, November 2007.
Immers, L.H. (2007b). Visie Incident Management, Verkeerscentrum Nederland, 2007.
Immers, L.H. and Landman, R. (2008). SMART goals for the application of Incident Management measures to the Dutch road network, TNO-rapport 2008-D-R0667/A, (in Dutch: SMART doelstellingen voor de toepassing van Incident Management maatregelen op het Nederlandse wegennet), Juni 2008.
Immers, L.H., Muller, M., Vonk, T., Kieviet, M. and Schrijver, J. (2009). Procesanalyse Incident Management: Zoektocht naar verbeteringsmaatregelen in het huidige IM proces. TNO-034-DTM-2009-04357.
Koehne, J., Mannering, F.L. and Hallenbeck, M.E. (1991). Framework for developing incident management system, Washington State Transportation Center, August 1991.
Komninos, N. (2002). *Intelligent Cities,* London, Spon Press.
Komninos, N. (2006). The architecture of intelligent cities; Integrating human, collective, and artificial intelligence to enhance knowledge and innovation. *2nd International Conference on Intelligent Environments.* Athens: Institution of Engineering and Technology.
Komninos, N. (2008). *Intelligent Cities and Globalisation of Innovation Networks,* Abingdon, Routledge.
Knibbe, W.J.J., Alkim, T.P., Otten, J.F.W., and Aidoo, M.Y. (2006). Automated Estimation of Incident Duration on Dutch Highways. In *Proceedings of IEEE ITS Conference*. Toronto, Canada.
Lassche, M. and Jacobs, C. (2009). Lessons from Washington. Results of a study trip to state services in Washington, USA for a comparison of incident clearance times. SPINlab (VU University Amsterdam). Research for the Dutch Ministry of Transport, Public Works and Water Management 2009.
Leopold, J.H. and Doornbos, H. (2009). Eindrapport kwalitatieve jaarmeting IM, Berenschot 2008.
McKinsey and Company (1995). Filearm wegbeheer (Eng: Tailback free traffic management), Ministerie van Verkeer en Vervoer, The Hague, in Dutch.
Mega, V. (2010). Future belongs to cities. *Regional symbiosis* 18, pp 1-13.
Mokhtarian, P.L. (2003). Telecommunications and travel: the case for complementarity. *Journal of Industrial Ecology* 6(2), pp. 43-57.
Nam, D. and Mannering, F. (2000). An Exploratory Hazard-Based Analysis of Highway Incident Duration, *Transportation Research Part A: Policy and Practice*, 34(2), pp. 85-102.
Nobis, C. and Lenz, B. (2009). Communication and mobility behaviour – a trend and panel analysis of the correlation between mobile phone use and mobility. *Journal of Transport Geography* 17 pp 93–103.

Nijkamp, P. and Kourtit, K. (2011). Joint Programming Initiative on Urban Europe. Global challenges and local responses in urban century. A scoping document. VU University Amsterdam, Februari 2011.

Özbay, K. and Kachroo, P. (1999). Incident Management for Intelligent Transportation Systems (ITS), Artech House, Massachusetts.

Ratti, C., Calabrese, F. and Kloeckl, K. (2007). WikiCity: Connecting the Tangible and the Virtual Realm of the City. *GEO Informatics*, 10(8), pp. 42-45.

Resch, B., Zipf, A., Breuss-Schneeweis, P., Beinat, E. and Boher, M. (2012**).** In: Proceedings of the 4th International Conference on Advanced Geographic Information Systems, Applications, and Services - GEOProcessing 2012, Valencia, Spain, January 30 - February 4 2012, pp. 28-34.

Rijkswaterstaatworks Management Act (1996). Staatsblad 1996, 645. Wetbeheer Rijkswaterstaatswerken. see: http://www.st-ab.nl/wetten/0399_Wet_beheer_rijkswaterstaatswerken.htm

Scholten and van der Vlist (2011). De inrichting van crisisbeheersing, de relatie tussen besluitvorming en informatievoorziening. Research Memorandum 2011-11, Free University Amsterdam. Faculty of Economics and Business Administration.

Skabardonis, A., Petty, K. F., Bertini, R. L., Varaiya, P. P., Noeimi, H., and Rydzewski, D. (1997). I-880 Field Experiment: Analysis of Incident Data, In *Transportation Research Record: Journal of the Transportation Research Board*, No. 1603, Transportation Research Board of the National Academies, Washington, D.C., pp. 72-79.

Steenbruggen, J., Nijkamp, P., Smits, J. and Grothe, M. (2012). Traffic Incident Management, A Common Operational Picture to support Situational Awareness of Sustainable Mobility, *International Journal of Transport Economics* Vol. XXXIX, No.1, pp. 131-170. March 2012.

Townsend, A. M. (2000). Life in the Real-Time City: Mobile Telephones and Urban Metabolism. *Journal of Urban Technology* 7, 85-104.

UK Highway Agency (2009). Traffic Incident Management Guidance Framework. Highway Agency and Association of Chief Police Officers, January 2009.

US Department of Homeland Security (2008). National Incident Management System, December 2008.

US Federal Highway Administration (1991). Traffic Incident Management Handbook.

US Federal Highway Administration (2000). Traffic Incident Management Handbook, Office of Travel Management.

US Federal Highway Administration (2010). Traffic Incident Management Handbook Update**,** Federal Highway Administration, Office of Transportation Operations.

Wegman F. (2007). Road traffic in the Netherlands: Relatively safe but not safe enough!, SWOV Institute for Road Safety Research, The Netherlands, AAA Foundation for Traffic Safety.

WGHOR (1991). Dutch Law on Medical Aid in Accidents and Disasters.

World Health Organization (2009). European status report on road safety. Towards safer roads and healthier transport choices, ISBN 978 92 890 4176 8.

Zwaneveld, P., Wilmink, I., Immers, B. Malipaard, E. and Heyse, D. (2000). An overview of Incident Management projects in the Netherlands. Peter Zwaneveld, Isabel Wilmink TNO Inro Ben Immers, TNO Inro and K.U. Leuven, Department of Civil Engineering Emst Malipaard, Grontmij, Dick Heyse Rijkswaterstaat, Projectbureau Incident Management.

2009-1	Boriana Rukanova Rolf T. Wignand Yao-Hua Tan	From national to supranational government inter-organizational systems: An extended typology, 33 p.
2009-2	Marc D. Bahlmann Marleen H. Huysman Tom Elfring Peter Groenewegen	Global Pipelines or global buzz? A micro-level approach towards the knowledge-based view of clusters, 33 p.
2009-3	Julie E. Ferguson Marleen H. Huysman	Between ambition and approach: Towards sustainable knowledge management in development organizations, 33 p.
2009-4	Mark G. Leijsen	Why empirical cost functions get scale economies wrong, 11 p.
2009-5	Peter Nijkamp Galit Cohen-Blankshtain	The importance of ICT for cities: e-governance and cyber perceptions, 14 p.
2009-6	Eric de Noronha Vaz Mário Caetano Peter Nijkamp	Trapped between antiquity and urbanism. A multi-criteria assessment model of the greater Cairo metropolitan area, 22 p.
2009-7	Eric de Noronha Vaz Teresa de Noronha Vaz Peter Nijkamp	Spatial analysis for policy evaluation of the rural world: Portuguese agriculture in the last decade, 16 p.
2009-8	Teresa de Noronha Vaz Peter Nijkamp	Multitasking in the rural world: Technological change and sustainability, 20 p.
2009-9	Maria Teresa Borzacchiello Vincenzo Torrieri Peter Nijkamp	An operational information systems architecture for assessing sustainable transportation planning: Principles and design, 17 p.
2009-10	Vincenzo Del Giudice Pierfrancesco De Paola Francesca Torrieri Francesca Pagliari Peter Nijkamp	A decision support system for real estate investment choice, 16 p.
2009-11	Miruna Mazurencu Marinescu Peter Nijkamp	IT companies in rough seas: Predictive factors for bankruptcy risk in Romania, 13 p.
2009-12	Boriana Rukanova Helle Zinner Hendriksen Eveline van Stijn Yao-Hua Tan	Bringing is innovation in a highly-regulated environment: A collective action perspective, 33 p.
2009-13	Patricia van Hemert Peter Nijkamp Jolanda Verbraak	Evaluating social science and humanities knowledge production: an exploratory analysis of dynamics in science systems, 20 p.

2009-14	Roberto Patuelli Aura Reggiani Peter Nijkamp Norbert Schanne	Neural networks for cross-sectional employment forecasts: A comparison of model specifications for Germany, 15 p.
2009-15	André de Waal Karima Kourtit Peter Nijkamp	The relationship between the level of completeness of a strategic performance management system and perceived advantages and disadvantages, 19 p.
2009-16	Vincenzo Punzo Vincenzo Torrieri Maria Teresa Borzacchiello Biagio Ciuffo Peter Nijkamp	Modelling intermodal re-balance and integration: planning a sub-lagoon tube for Venezia, 24 p.
2009-17	Peter Nijkamp Roger Stough Mediha Sahin	Impact of social and human capital on business performance of migrant entrepreneurs – a comparative Dutch-US study, 31 p.
2009-18	Dres Creal	A survey of sequential Monte Carlo methods for economics and finance, 54 p.
2009-19	Karima Kourtit André de Waal	Strategic performance management in practice: Advantages, disadvantages and reasons for use, 15 p.
2009-20	Karima Kourtit André de Waal Peter Nijkamp	Strategic performance management and creative industry, 17 p.
2009-21	Eric de Noronha Vaz Peter Nijkamp	Historico-cultural sustainability and urban dynamics – a geo-information science approach to the Algarve area, 25 p.
2009-22	Roberta Capello Peter Nijkamp	Regional growth and development theories revisited, 19 p.
2009-23	M. Francesca Cracolici Miranda Cuffaro Peter Nijkamp	Tourism sustainability and economic efficiency – a statistical analysis of Italian provinces, 14 p.
2009-24	Caroline A. Rodenburg Peter Nijkamp Henri L.F. de Groot Erik T. Verhoef	Valuation of multifunctional land use by commercial investors: A case study on the Amsterdam Zuidas mega-project, 21 p.
2009-25	Katrin Oltmer Peter Nijkamp Raymond Florax Floor Brouwer	Sustainability and agri-environmental policy in the European Union: A meta-analytic investigation, 26 p.
2009-26	Francesca Torrieri Peter Nijkamp	Scenario analysis in spatial impact assessment: A methodological approach, 20 p.
2009-27	Aliye Ahu Gülümser Tüzin Baycan-Levent Peter Nijkamp	Beauty is in the eyes of the beholder: A logistic regression analysis of sustainability and locality as competitive vehicles for human settlements, 14 p.

2009-28	Marco Percoco Peter Nijkamp	Individual time preferences and social discounting in environmental projects, 24 p.
2009-29	Peter Nijkamp Maria Abreu	Regional development theory, 12 p.
2009-30	Tüzin Baycan-Levent Peter Nijkamp	7 FAQs in urban planning, 22 p.
2009-31	Aliye Ahu Gülümser Tüzin Baycan-Levent Peter Nijkamp	Turkey's rurality: A comparative analysis at the EU level, 22 p.
2009-32	Frank Bruinsma Karima Kourtit Peter Nijkamp	An agent-based decision support model for the development of e-services in the tourist sector, 21 p.
2009-33	Mediha Sahin Peter Nijkamp Marius Rietdijk	Cultural diversity and urban innovativeness: Personal and business characteristics of urban migrant entrepreneurs, 27 p.
2009-34	Peter Nijkamp Mediha Sahin	Performance indicators of urban migrant entrepreneurship in the Netherlands, 28 p.
2009-35	Manfred M. Fischer Peter Nijkamp	Entrepreneurship and regional development, 23 p.
2009-36	Faroek Lazrak Peter Nijkamp Piet Rietveld Jan Rouwendal	Cultural heritage and creative cities: An economic evaluation perspective, 20 p.
2009-37	Enno Masurel Peter Nijkamp	Bridging the gap between institutions of higher education and small and medium-size enterprises, 32 p.
2009-38	Francesca Medda Peter Nijkamp Piet Rietveld	Dynamic effects of external and private transport costs on urban shape: A morphogenetic perspective, 17 p.
2009-39	Roberta Capello Peter Nijkamp	Urban economics at a cross-yard: Recent theoretical and methodological directions and future challenges, 16 p.
2009-40	Enno Masurel Peter Nijkamp	The low participation of urban migrant entrepreneurs: Reasons and perceptions of weak institutional embeddedness, 23 p.
2009-41	Patricia van Hemert Peter Nijkamp	Knowledge investments, business R&D and innovativeness of countries. A qualitative meta-analytic comparison, 25 p.
2009-42	Teresa de Noronha Vaz Peter Nijkamp	Knowledge and innovation: The strings between global and local dimensions of sustainable growth, 16 p.
2009-43	Chiara M. Travisi Peter Nijkamp	Managing environmental risk in agriculture: A systematic perspective on the potential of quantitative policy-oriented risk valuation, 19 p.
2009-44	Sander de Leeuw	Logistics aspects of emergency preparedness in flood disaster prevention, 24 p.

	Iris F.A. Vis Sebastiaan B. Jonkman	
2009-45	Eveline S. van Leeuwen Peter Nijkamp	Social accounting matrices. The development and application of SAMs at the local level, 26 p.
2009-46	Tibert Verhagen Willemijn van Dolen	The influence of online store characteristics on consumer impulsive decision-making: A model and empirical application, 33 p.
2009-47	Eveline van Leeuwen Peter Nijkamp	A micro-simulation model for e-services in cultural heritage tourism, 23 p.
2009-48	Andrea Caragliu Chiara Del Bo Peter Nijkamp	Smart cities in Europe, 15 p.
2009-49	Faroek Lazrak Peter Nijkamp Piet Rietveld Jan Rouwendal	Cultural heritage: Hedonic prices for non-market values, 11 p.
2009-50	Eric de Noronha Vaz João Pedro Bernardes Peter Nijkamp	Past landscapes for the reconstruction of Roman land use: Eco-history tourism in the Algarve, 23 p.
2009-51	Eveline van Leeuwen Peter Nijkamp Teresa de Noronha Vaz	The Multi-functional use of urban green space, 12 p.
2009-52	Peter Bakker Carl Koopmans Peter Nijkamp	Appraisal of integrated transport policies, 20 p.
2009-53	Luca De Angelis Leonard J. Paas	The dynamics analysis and prediction of stock markets through the latent Markov model, 29 p.
2009-54	Jan Anne Annema Carl Koopmans	Een lastige praktijk: Ervaringen met waarderen van omgevingskwaliteit in de kosten-batenanalyse, 17 p.
2009-55	Bas Straathof Gert-Jan Linders	Europe’s internal market at fifty: Over the hill? 39 p.
2009-56	Joaquim A.S. Gromicho Jelke J. van Hoorn Francisco Saldanha-da-Gama Gerrit T. Timmer	Exponentially better than brute force: solving the job-shop scheduling problem optimally by dynamic programming, 14 p.
2009-57	Carmen Lee Roman Kraeussl Leo Paas	The effect of anticipated and experienced regret and pride on investors’ future selling decisions, 31 p.
2009-58	René Sitters	Efficient algorithms for average completion time scheduling, 17 p.

2009-59	Masood Gheasi Peter Nijkamp Piet Rietveld	Migration and tourist flows, 20 p.

2010-1	Roberto Patuelli Norbert Schanne Daniel A. Griffith Peter Nijkamp	Persistent disparities in regional unemployment: Application of a spatial filtering approach to local labour markets in Germany, 28 p.
2010-2	Thomas de Graaff Ghebre Debrezion Piet Rietveld	Schaalsprong Almere. Het effect van bereikbaarheidsverbeteringen op de huizenprijzen in Almere, 22 p.
2010-3	John Steenbruggen Maria Teresa Borzacchiello Peter Nijkamp Henk Scholten	Real-time data from mobile phone networks for urban incidence and traffic management – a review of application and opportunities, 23 p.
2010-4	Marc D. Bahlmann Tom Elfring Peter Groenewegen Marleen H. Huysman	Does distance matter? An ego-network approach towards the knowledge-based theory of clusters, 31 p.
2010-5	Jelke J. van Hoorn	A note on the worst case complexity for the capacitated vehicle routing problem, 3 p.
2010-6	Mark G. Lijesen	Empirical applications of spatial competition; an interpretative literature review, 16 p.
2010-7	Carmen Lee Roman Kraeussl Leo Paas	Personality and investment: Personality differences affect investors’ adaptation to losses, 28 p.
2010-8	Nahom Ghebrihiwet Evgenia Motchenkova	Leniency programs in the presence of judicial errors, 21 p.
2010-9	Meindert J. Flikkema Ard-Pieter de Man Matthijs Wolters	New trademark registration as an indicator of innovation: results of an explorative study of Benelux trademark data, 53 p.
2010-10	Jani Merikivi Tibert Verhagen Frans Feldberg	Having belief(s) in social virtual worlds: A decomposed approach, 37 p.
2010-11	Umut Kilinç	Price-cost markups and productivity dynamics of entrant plants, 34 p.
2010-12	Umut Kilinç	Measuring competition in a frictional economy, 39 p.

2011-1	Yoshifumi Takahashi Peter Nijkamp	Multifunctional agricultural land use in sustainable world, 25 p.
2011-2	Paulo A.L.D. Nunes Peter Nijkamp	Biodiversity: Economic perspectives, 37 p.
2011-3	Eric de Noronha Vaz Doan Nainggolan Peter Nijkamp Marco Painho	A complex spatial systems analysis of tourism and urban sprawl in the Algarve, 23 p.
2011-4	Karima Kourtit Peter Nijkamp	Strangers on the move. Ethnic entrepreneurs as urban change actors, 34 p.
2011-5	Manie Geyer Helen C. Coetzee Danie Du Plessis Ronnie Donaldson Peter Nijkamp	Recent business transformation in intermediate-sized cities in South Africa, 30 p.
2011-6	Aki Kangasharju Christophe Tavéra Peter Nijkamp	Regional growth and unemployment. The validity of Okun's law for the Finnish regions, 17 p.
2011-7	Amitrajeet A. Batabyal Peter Nijkamp	A Schumpeterian model of entrepreneurship, innovation, and regional economic growth, 30 p.
2011-8	Aliye Ahu Akgün Tüzin Baycan Levent Peter Nijkamp	The engine of sustainable rural development: Embeddedness of entrepreneurs in rural Turkey, 17 p.
2011-9	Aliye Ahu Akgün Eveline van Leeuwen Peter Nijkamp	A systemic perspective on multi-stakeholder sustainable development strategies, 26 p.
2011-10	Tibert Verhagen Jaap van Nes Frans Feldberg Willemijn van Dolen	Virtual customer service agents: Using social presence and personalization to shape online service encounters, 48 p.
2011-11	Henk J. Scholten Maarten van der Vlist	De inrichting van crisisbeheersing, de relatie tussen besluitvorming en informatievoorziening. Casus: Warroom project Netcentrisch werken bij Rijkswaterstaat, 23 p.
2011-12	Tüzin Baycan Peter Nijkamp	A socio-economic impact analysis of cultural diversity, 22 p.
2011-13	Aliye Ahu Akgün Tüzin Baycan Peter Nijkamp	Repositioning rural areas as promising future hot spots, 22 p.
2011-14	Selmar Meents Tibert Verhagen Paul Vlaar	How sellers can stimulate purchasing in electronic marketplaces: Using information as a risk reduction signal, 29 p.

2011-15	Aliye Ahu Gülümser Tüzin Baycan-Levent Peter Nijkamp	Measuring regional creative capacity: A literature review for rural-specific approaches, 22 p.
2011-16	Frank Bruinsma Karima Kourtit Peter Nijkamp	Tourism, culture and e-services: Evaluation of e-services packages, 30 p.
2011-17	Peter Nijkamp Frank Bruinsma Karima Kourtit Eveline van Leeuwen	Supply of and demand for e-services in the cultural sector: Combining top-down and bottom-up perspectives, 16 p.
2011-18	Eveline van Leeuwen Peter Nijkamp Piet Rietveld	Climate change: From global concern to regional challenge, 17 p.
2011-19	Eveline van Leeuwen Peter Nijkamp	Operational advances in tourism research, 25 p.
2011-20	Aliye Ahu Akgün Tüzin Baycan Peter Nijkamp	Creative capacity for sustainable development: A comparative analysis of European and Turkish rural regions, 18 p.
2011-21	Aliye Ahu Gülümser Tüzin Baycan-Levent Peter Nijkamp	Business dynamics as the source of counterurbanisation: An empirical analysis of Turkey, 18 p.
2011-22	Jessie Bakens Peter Nijkamp	Lessons from migration impact analysis, 19 p.
2011-23	Peter Nijkamp Galit Cohen-blankshtain	Opportunities and pitfalls of local e-democracy, 17 p.
2011-24	Maura Soekijad Irene Skovgaard Smith	The ‘lean people’ in hospital change: Identity work as social differentiation, 30 p.
2011-25	Evgenia Motchenkova Olgerd Rus	Research joint ventures and price collusion: Joint analysis of the impact of R&D subsidies and antitrust fines, 30 p.
2011-26	Karima Kourtit Peter Nijkamp	Strategic choice analysis by expert panels for migration impact assessment, 41 p.
2011-27	Faroek Lazrak Peter Nijkamp Piet Rietveld Jan Rouwendal	The market value of listed heritage: An urban economic application of spatial hedonic pricing, 24 p.
2011-28	Peter Nijkamp	Socio-economic impacts of heterogeneity among foreign migrants: Research and policy challenges, 17 p.
2011-29	Masood Gheasi Peter Nijkamp	Migration, tourism and international trade: Evidence from the UK, 8 p.
2011-30	Karima Kourtit	Evaluation of cyber-tools in cultural tourism, 24 p.

	Peter Nijkamp Eveline van Leeuwen Frank Bruinsma	
2011-31	Cathy Macharis Peter Nijkamp	Possible bias in multi-actor multi-criteria transportation evaluation: Issues and solutions, 16 p.
2011-32	John Steenbruggen Maria Teresa Borzacchiello Peter Nijkamp Henk Scholten	The use of GSM data for transport safety management: An exploratory review, 29 p.
2011-33	John Steenbruggen Peter Nijkamp Jan M. Smits Michel Grothe	Traffic incident management: A common operational picture to support situational awareness of sustainable mobility, 36 p.
2011-34	Tüzin Baycan Peter Nijkamp	Students' interest in an entrepreneurial career in a multicultural society, 25 p.
2011-35	Adele Finco Deborah Bentivoglio Peter Nijkamp	Integrated evaluation of biofuel production options in agriculture: An exploration of sustainable policy scenarios, 16 p.
2011-36	Eric de Noronha Vaz Pedro Cabral Mário Caetano Peter Nijkamp Marco Paínho	Urban heritage endangerment at the interface of future cities and past heritage: A spatial vulnerability assessment, 25 p.
2011-37	Maria Giaoutzi Anastasia Stratigea Eveline van Leeuwen Peter Nijkamp	Scenario analysis in foresight: AG2020, 23 p.
2011-38	Peter Nijkamp Patricia van Hemert	Knowledge infrastructure and regional growth, 12 p.
2011-39	Patricia van Hemert Enno Masurel Peter Nijkamp	The role of knowledge sources of SME's for innovation perception and regional innovation policy, 27 p.
2011-40	Eric de Noronha Vaz Marco Painho Peter Nijkamp	Impacts of environmental law and regulations on agricultural land-use change and urban pressure: The Algarve case, 18 p.
2011-41	Karima Kourtit Peter Nijkamp Steef Lowik Frans van Vught Paul Vulto	From islands of innovation to creative hotspots, 26 p.
2011-42	Alina Todiras Peter Nijkamp Saidas Rafijevas	Innovative marketing strategies for national industrial flagships: Brand repositioning for accessing upscale markets, 27 p.

2011-43	Eric de Noronha Vaz Mário Caetano Peter Nijkamp	A multi-level spatial urban pressure analysis of the Giza Pyramid Plateau in Egypt, 18 p.
2011-44	Andrea Caragliu Chiara Del Bo Peter Nijkamp	A map of human capital in European cities, 36 p.
2011-45	Patrizia Lombardi Silvia Giordano Andrea Caragliu Chiara Del Bo Mark Deakin Peter Nijkamp Karima Kourtit	An advanced triple-helix network model for smart cities performance, 22 p.
2011-46	Jessie Bakens Peter Nijkamp	Migrant heterogeneity and urban development: A conceptual analysis, 17 p.
2011-47	Irene Casas Maria Teresa Borzacchiello Biagio Ciuffo Peter Nijkamp	Short and long term effects of sustainable mobility policy: An exploratory case study, 20 p.
2011-48	Christian Bogmans	Can globalization outweigh free-riding? 27 p.
2011-49	Karim Abbas Bernd Heidergott Djamil Aïssani	A Taylor series expansion approach to the functional approximation of finite queues, 26 p.
2011-50	Eric Koomen	Indicators of rural vitality. A GIS-based analysis of socio-economic development of the rural Netherlands, 17 p.

2012-1	Aliye Ahu Gülümser Tüzin Baycan Levent Peter Nijkamp Jacques Poot	The role of local and newcomer entrepreneurs in rural development: A comparative meta-analytic study, 39 p.
2012-2	Joao Romao Bart Neuts Peter Nijkamp Eveline van Leeuwen	Urban tourist complexes as Multi-product companies: Market segmentation and product differentiation in Amsterdam, 18 p.
2012-3	Vincent A.C. van den Berg	Step tolling with price sensitive demand: Why more steps in the toll makes the consumer better off, 20 p.
2012-4	Vasco Diogo Eric Koomen Floor van der Hilst	Second generation biofuel production in the Netherlands. A spatially-explicit exploration of the economic viability of a perennial biofuel crop, 12 p.
2012-5	Thijs Dekker Paul Koster Roy Brouwer	Changing with the tide: Semi-parametric estimation of preference dynamics, 50 p.
2012-6	Daniel Arribas Karima Kourtit Peter Nijkamp	Benchmarking of world cities through self-organizing maps, 22 p.
2012-7	Karima Kourtit Peter Nijkamp Frans van Vught Paul Vulto	Supernova stars in knowledge-based regions, 24 p.
2012-8	Mediha Sahin Tüzin Baycan Peter Nijkamp	The economic importance of migrant entrepreneurship: An application of data envelopment analysis in the Netherlands, 16 p.
2012-9	Peter Nijkamp Jacques Poot	Migration impact assessment: A state of the art, 48 p.
2012-10	Tibert Verhagen Anniek Nauta Frans Feldberg	Negative online word-of-mouth: Behavioral indicator or emotional release? 29 p.

2013-1	Tüzin Baycan Peter Nijkamp	The migration development nexus: New perspectives and challenges, 22 p.
2013-2	Haralambie Leahu	European Options Sensitivities via Monte Carlo Techniques, 28 p.
2013-3	Tibert Verhagen Charlotte Vonkeman Frans Feldberg Plon Verhagen	Making online products more tangible and likeable: The role of local presence as product presentation mechanism, 44 p.
2013-4	Aliye Ahu Akgün Eveline van Leeuwen Peter Nijkamp	A Multi-actor multi-criteria scenario analysis of regional sustainable resource policy, 24 p.
2013-5	John Steenbruggen Peter Nijkamp Maarten van der Vlist	Urban traffic incident management in a digital society. An actor-network approach in information technology use in urban Europe, 25 p.